

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number  
WO 01/19025 A2

(51) International Patent Classification<sup>7</sup>: H04L 12/00

Donald, L.; 2721 19th street, Greeley, CO 80634 (US).  
COOK, Charles, I.; 182 Cherrywood Lane, Louisville, CO 80027 (US). WELLS, Guy, M.; 480 West Street, Louisville, CO 80027 (US).

(21) International Application Number: PCT/US00/24510

(74) Agents: CHUEY, Mark, D. et al.; Brooks & Kushman, Twenty-Second Floor, 1000 Town Center, Southfield, MI 48075 (US).

(22) International Filing Date:  
6 September 2000 (06.09.2000)

(81) Designated States (national): CA, KR, MX.

(25) Filing Language: English

(84) Designated States (regional): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

(26) Publication Language: English

Published:

(30) Priority Data:  
60/152,730 8 September 1999 (08.09.1999) US  
09/505,271 16 February 2000 (16.02.2000) US  
60/185,788 29 February 2000 (29.02.2000) US  
09/603,035 23 June 2000 (23.06.2000) US  
09/603,123 23 June 2000 (23.06.2000) US

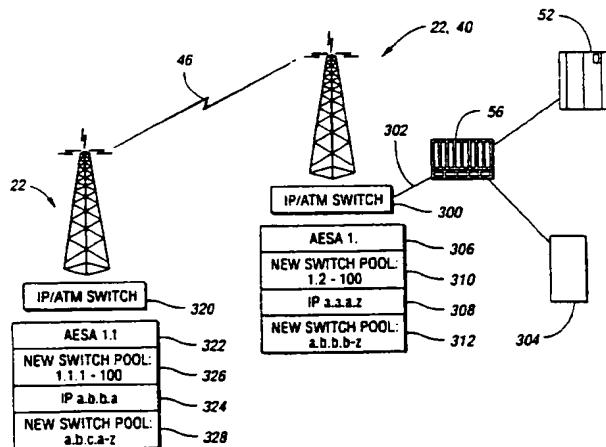
— Without international search report and to be republished upon receipt of that report.

(71) Applicant: QWEST COMMUNICATIONS INTERNATIONAL INC. [US/US]; 1801 California Street, 38th floor, Denver, CO 80202 (US).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(72) Inventors: DOUGHERTY, Angus, O.; 11281 Ranch Place, Westminster, CO 80234 (US). HOHNSTEIN,

(54) Title: SYSTEM AND METHOD FOR DYNAMIC DISTRIBUTED COMMUNICATION



WO 01/19025 A2

(57) Abstract: Growth of a distributed communication system (20) is facilitated through dynamic addition of distribution elements (22, 40, 50). A new element may be added to a network of elements by first establishing a connection (42, 44, 46, 48) between the new element and an existing element in the network. At least one address (322, 324) is assigned to the new element from a pool of addresses (310, 312) maintained at the existing element. At least one pool of addresses (326, 328) is issued to the new element, permitting the new element to dynamically add another new element. Information packets are routed through the network by determining a forwarding equivalency class (FEC) (400) for each subscriber unit (26) accessing the network. The FEC to which each subscriber unit belongs is based on the point (22) at which the subscriber unit accesses the network. Information packets are routed from a distribution element (40, 50) by determining the next element (22, 40, 50) based on the FEC for the destination subscriber unit.

## SYSTEM AND METHOD FOR DYNAMIC DISTRIBUTED COMMUNICATION

### TECHNICAL FIELD

The present invention relates to dynamically modifying  
5 communication network components and communication paths.

### BACKGROUND ART

Communication systems are increasingly required to provide a wide range of services, including different forms of information communicated with different communication characteristics. Information forms include voice, data, 10 video, telemetry, and the like. Communication characteristics include quality, complexity, latency, reliability, cost, availability, portability, and the like. Infrastructure such as telecommunication systems, the Internet, and cable systems exist to provide long-haul routing and information content sourcing. However, difficulty remains in delivering this information to customers. This is particularly 15 the case if the customer is located in a rural location, is communicating through portable equipment, or is mobile.

Traditionally, communication service providers have relied on copper wire or coaxial cable to connect distribution sites and subscriber premises. However, increases in the number of users, number and type of communication 20 devices per user, and the information rate per device has strained the ability for traditional communication systems to provide the necessary bandwidth and flexibility. Various technologies including digital subscriber line (DSL) and video modems offer broadband access to the subscriber over existing copper or coaxial loop technologies. Fiber-to-the-home offers broadband access through additional 25 wireline connections. While each technology has broadband delivery properties, each is subject to physical and signaling limitations that restrict availability in certain locations and for certain applications. For example, VDSL is limited to within

approximately one kilometer of a connecting central office. Further, each central office usually cannot support high-speed access for every customer within the central office coverage area. Similarly, service provided by two-way cable modems is limited to the installation of coax, hybrid fiber coax and fiber-based systems by the 5 cable provider as well as capabilities of the supporting central office. Currently, many premises do not have access to high-speed wireline voice, data, and video services due, in part, to the expense and difficulty in constructing or expanding central offices.

Wireless systems, such as PCS and cellular systems, offer an 10 alternative to wireline services. Typically, wireless systems include a centralized mobile switching center (MSC) responsible for routing calls, tracking user locations, billing information, and connectivity with other communication systems. The MSC is connected to base station controllers (BSCs), each of which supports one or more 15 base transceiver stations (BTSs). Each BTS supports one or more cells based on the number and configuration of antennas supported by the BTS. Customers communicate with the wireless system through radio telephones when the telephone is within the coverage range of a cell. When a call is placed, a circuit-switched connection is established from the telephone, through the BTS and BSC, to the MSC. The MSC determines the destination and, if the destination is to another telephone 20 within the wireless system, establishes a circuit-switched connection to the destination telephone. If the destination is outside of the wireless system, the MSC routes the call to a service provider for the outside destination.

Cellular and PCS wireless systems have traditionally focused on 25 voice. However, recent introduction of digital radio in both the 800 MHz and 1.9 GHz ranges permits low-speed data services, such as text messaging and one-way paging, to be implemented. Also, wireless modems implementing wireless application protocols may be incorporated into hand-held devices such as lap top personal computers and personal digital assistants (PDAs). Such devices may offer access to the Internet at rates up to 19.2 kilobits per second.

Several problems have developed with traditional wireless systems. First, because all calls are processed by the central MSC, it can become a bottleneck limiting the number of users supported. Second, if the MSC fails, the system becomes inoperative. Third, the BSC and BTS architecture is fairly rigid, requiring 5 manual reconfiguration in the MSC when components are added or deleted. Fourth, circuit-switched channel connections establish an upper bandwidth, limiting communication rates. Fifth, bandwidth is wasted if the communication rate does not reach the maximum established by the communication channel. Sixth, high-speed data and video applications are impractical on wireless telecommunication systems 10 designed primarily for voice.

An alternative wireless communication system is the multi-channel multipoint distribution system (MMDS). In MMDS, an antenna broadcasts high-bandwidth content to local receiving antennas. In the case of Internet access, the return path is typically through slow telephone lines. MMDS, like wireline cable 15 systems, is asymmetrical, making it best suited for distribution of one-way entertainment signals such as television. MMDS also typically operates at a higher carrier frequency than PCS systems, requiring receiving antennas to be positioned in line-of-site with the transmitting antenna. MMDS is typically deployed in a single cell broadcast architecture. Other wireless communication systems, such as local 20 multipoint distribution system (LMDS) may be deployed in a cellular fashion. However, because these systems typically operate at a high carrier frequency, receiving antennas must be positioned in line-of-sight with the transmitting antenna.

What is needed is a communication system that provides voice, data, and video signals at rates appropriate for each user. The system should make 25 efficient use of bandwidth, allocating only the bandwidth necessary for a particular communication. The system should be flexible, permitting automatic addition and deletion of network components. The system should have distributed routing and service provisioning to prevent bottlenecks, permit scaling, and increase reliability and robustness. The system should support wireless subscriber units, 30 accommodating a wide variety of fixed, portable, and mobile user communication devices. The system should support high-speed symmetric and asymmetric

communication for applications such as video conferencing, real-time distributed document sharing, and the like. The system should also easily and rapidly adapt to mobile and portable users that change location throughout the communication system.

5

## DISCLOSURE OF INVENTION

The present invention provides automatic and dynamic addition of network routing or distribution elements to a distributed communication network. This permits rapid, scalable, and inexpensive growth of the communication network, allowing for a flexible system that can be easily modified to meet customer needs, 10 balance resources, and satisfy physical constraints and government regulations. The present invention also provides automatic and flexible routing of information packet through a distributed communication system. This permits users to enter the communication system at any point and to freely move about within the communication system without having to register or otherwise manually notify the 15 communication system.

A new routing element may be dynamically added to a network of routing elements by first establishing a connection between the new routing element and an existing routing element in the network. The connection may be either wireless or wireline. At least one address is assigned to the new routing element. 20 Each assigned address comes from a pool of addresses maintained at the existing routing element. At least one pool of addresses is issued to the new routing element, permitting the new routing element to dynamically add yet another new routing element to the network of routing elements.

The assigned address may be one or more from a set including an 25 ATM address and an IP address. Likewise, address pools may be pools of ATM addresses and pools of IP addresses. Other types of addresses may be included or substituted, such as TCP, 802.x, and the like. Any assignable address that can distinguish between network elements may be used.

In one embodiment, a supervisor supplies pools of ATM end user addresses and pools of IP addresses. Each distribution point obtains a pool of ATM end user addresses and a pool of IP addresses from the supervisor. When a distribution point receives a request from a new network element to join the network, the distribution point provides the new network element with an ATM end user address from the pool of ATM end user addresses and an IP address from the pool of IP addresses. An access point may also receive address pools and function as a distribution point in support of additional access points.

Information packets are routed through the distributed routing network by determining a forwarding equivalency class (FEC) for each subscriber unit accessing the network. The FEC to which each subscriber unit belongs is based on the point at which the subscriber unit accesses the network. The forwarding equivalency class for each subscriber unit is updated if the subscriber unit accesses the network at a different point. Information packets are routed from a distribution point by determining the next point connected to the distribution point based on the FEC for the destination subscriber unit specified in the packet. Packets are preferably IP packets, but any form of packetized information may be routed in this manner.

Routing elements may be of a variety of types. Any distribution element that receives or forwards information packets may be used. For example, routing elements may include distribution points and access points in a communication network. In one aspect of the present invention, distribution points form peer-to-peer relationships with each other. Access points form client-server relationships with distribution points. If multiple addresses are assigned to each routing element, relationships between routing elements may be established concurrently across more than one layer. For example, IP routing may be established at the network layer and ATM switching at the data link layer with routing elements communicating in a peer-to-peer or client-server relationship at each layer.

Updating of forwarding equivalency classes may be accomplished by several techniques. An access point determining that a new subscriber unit seeks access to the communication system through itself may broadcast this information to the distribution points. Similarly, an access point determining that a subscriber unit is no longer accessing the communication system through itself may broadcast this information. The communication system may also include a supervisor in contact with the distribution points for determining membership in forwarding equivalency classes.

The above objects and features as well as other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

#### **BRIEF DESCRIPTION OF DRAWINGS**

FIGURE 1 is a schematic drawing illustrating a portion of a communication system according to an embodiment of the present invention;

FIGURE 2 is a block diagram of a distribution point according to an embodiment of the present invention;

FIGURE 3 is a schematic drawing illustrating an implementation of a communication system according to an embodiment of the present invention;

FIGURE 4 is a schematic drawing illustrating an initial state for a communication system according to an embodiment of the present invention;

FIGURE 5 is a schematic drawing illustrating the addition of a second access point to the communication system of Figure 4 according to an embodiment of the present invention;

FIGURE 6 is a schematic drawing illustrating a hierarchical routing system using ATM/IP switches according to an embodiment of the present invention;

FIGURE 7 is a schematic drawing illustrating a network of distribution points routing packets based on forward equivalency classes; and

5 FIGURE 8 is a schematic drawing illustrating forward equivalency class updating to track a moving subscriber unit.

### BEST MODE FOR CARRYING OUT THE INVENTION

Referring to Figure 1, a schematic drawing illustrating a portion of a communication system according to an embodiment of the present invention is shown. A communication system, shown generally by 20, includes a plurality of access points 22 which may be, for example, a local radio access point (LRAP). Each access point 22 defines coverage area 24 such as, for example, a cell, covering a reception range of access point 22. Coverage area 24 may be formed from many independent sectors, as may result if access point 22 uses many unidirectional antennas, or may be a single region resulting from the use of an omnidirectional antenna. Subscriber unit 26 within coverage area 24 may establish two-way wireless link 28 with access point 22. Subscriber unit 26 may also establish wireline link 29 with access point 22. Links 28, 29 may be symmetrical or asymmetrical. Subscriber unit 26 may be fixed or non-fixed and, if non-fixed, may possess varying degrees of portability and mobility. Subscriber unit 26 may be a mobile telephone, a computer, a video receiver, an audio receiver, a two-way video conferencing station, a video game, an information kiosk, a remote sensor, a remote actuator, or any other suitable communication device.

Wireless link 28 may be any form of electromagnetic signaling not confined to a wire or cable, including energy radiated by antenna as well as visible and invisible light. As will be appreciated by one of ordinary skill in the art, wireless link 28 may be implemented by any access technology, including CDMA, TDMA, FDMA, OFDM, analog, and the like. Modulation techniques that may be

used with the present invention include FSK, BPSK, QPSK, m-ary QAM, FM, AM, and the like. Further, the invention does not depend on modulation frequency or on the use of FDD or TDD. In a preferred embodiment, the access technology, frequency, and modulation method for establishing wireless link 28 are based, in 5 part, on local geography, local regulations, noise and distortion sources, other operating wireless systems, cost, or any other suitable parameter. Subscriber unit 26 and access point 22 may establish wireless link 28 using a plurality of combinations of access technology, frequency, and modulation techniques.

Information transmitted on links 28, 29 may represent voice, data, 10 video, streaming audio, streaming video, or the like. Types of information include speech, facsimile, computer data, entertainment and informational audio and video, video game data, telemetry information, security information, and the like. If the information occurs as a continuous stream, subscriber unit 26 breaks the information into packets prior to packet transmission and reassembles the information stream 15 from packets after packet reception. Any type of information that exists in packets or that may be packetized can be used with the present invention.

In an embodiment of the present invention, subscriber unit 26 may be implemented as part of terminal network controller 30 accepting inputs from and providing outputs to information sources including voice equipment 32, computing equipment 34, telemetry equipment 36, video equipment 38, or any other suitable communication equipment. Inputs to terminal network controller 30 may include 20 serial data, parallel data, ISDN, standard telephone, xDSL, SR 1394, coaxial cable, twisted pair cable, optical fiber, or any other suitable communication protocol, method, or medium.

25 In an embodiment of the present invention, a quality error bit rate is established for each subscriber unit 26. This quality error bit rate may be based on the location of subscriber unit 26 within communication system 20, the class of service assigned to subscriber unit 26, the grade of service assigned to subscriber 30 unit 26, the data or transmission rate of service assigned to subscriber unit 26, or any other suitable parameter. The quality error bit rate may be modified while

subscriber unit 26 is within communication system 20 to reflect changing conditions such as noise, demand, connectivity, or any other suitable parameter. Applications providing services to subscriber unit 26 may adjust these services based on the quality error bit rate. For example, an application providing streaming audio and 5 video may reduce the frame update rate as noise increases, guaranteeing successful transmission at a lower information rate. The information rate may be further reduced to provide only still pictures and audio if conditions continue to worsen. The information rate may also be automatically changed if subscriber unit 26 moves between coverage areas 24 with differing transmission capabilities or loads.

10 Control of the information rate may be achieved by having subscriber unit 26 monitor a signaling channel transmitted by access point 22 for each coverage area 24. This signaling channel informs subscriber unit 26 when to transmit information, how much information to transmit, the information transmission rate, and the like. The signaling channel may be controlled by a central supervisor, 15 described below.

In an embodiment of the present invention, bandwidth on communication link 28 is only consumed when packets containing information are transmitted. For example, each subscriber unit 26 surrenders bandwidth on communication link 28 when not sending or receiving an information packet. 20 Packets to be transmitted are queued based on order of arrival, priority, a combination of arrival order and priority, or the like. Subscriber unit 26 monitors a signaling channel transmitted by access point 22 for each coverage area 24. Subscriber unit 26 only consumes bandwidth when instructed to transmit by the signaling channel or when receiving packets.

25 Each access point 22 communicates with at least one distribution point 40. Distribution point 40 contains both routing and switching functionality. Access point 22 may be in contact with one or more radio access distribution points 40 over radio link 42, may be wired or cabled to distribution point 40 through wireline link 44, or may be packaged with distribution point 40. Access point 22 may also be 30 transformed into distribution point 40, permitting access point 22 to route traffic that

neither originated nor terminated with any of its serviced subscriber units 26. Distribution point 40 is in communication with at least one additional distribution point 40, the collection of interconnected distribution points forming a network of distribution points, shown generally by 41. Two distribution points may be  
5 connected by radio link 46 or wireline link 48.

Distribution points 40 may route packets within distribution point network 41 under a variety of protocols such as ATM, TCP/IP, 802.x, or the like. In a preferred embodiment, distribution point 40 includes an ATM/IP switch. Distribution point 40 then operates at both the IP routing and ATM switching layers  
10 or, in terms of the Open Systems Interconnection (OSI) standard, at both the network layer and the data link layer.

The IP layer operates with a link-state protocol such as the open shortest path first (OSPF), quality OSPF (Q-OSPF), or internal gateway routing protocol (IGRP) and its derivatives. The IP layer operates as a single autonomous  
15 system (AS) within the IP frame of reference. Each system 20 will be allocated a unique and unambiguous AS number for system management. IP addresses for system 20 will use a private IP address space that cannot be routed within public systems such as the Internet. Subscriber units 26 within system 20 may be permitted access to the private IP address space or may be excluded from the private IP address space. When private IP address space is used for subscriber units 26, a  
20 network address translator (NAT) within system 20 allows subscriber units 26 access to the Internet. The ATM layer operates with the private network node interface (PNNI) routing protocol. ATM end system addresses (AESAs), managed by the service provider for system 20, are used by distribution point network 41.

25 The ATM network carries voice traffic and may carry data. Through PNNI, the ATM/IP switch participates in switched or signaled virtual connections (SVCs). When subscriber unit 26 within system 20 requires voice connectivity, it signals such a request, which is serviced by distribution point 40 receiving that request. The IP network coresiding with the ATM network is used for delay  
30 insensitive data applications required by subscriber units 26. The IP network is also

used for all network management, including management of ATM/IP switches, subscriber units 26, gear associated with distribution points 40, and any other suitable network component. This includes functions such as alarming, monitoring, recovery systems, and the like. While described in the context of a wireless network 5 application, it is readily apparent that ATM/IP routing as described herein may be applied to wireline and mixed wireline-wireless systems as well.

Each distribution point 40 receives an information packet from either another distribution point 40, from subscriber unit 26 in communication with distribution point 40 through access point 22, or from an external communication 10 system. If distribution point 40 determines the information packet is destined for subscriber unit 26 within coverage area 24 of access point 22 in communication with distribution point 40, distribution point 40 forwards the packet to access point 22 forming coverage area 24 containing destination subscriber unit 26. If distribution point 40 determines the information packet is destined for subscriber unit 26 in 15 coverage area 24 formed by access point 22 in communication with a different distribution point 40, distribution point 40 forwards the packet to one of distribution points 40 in communication with distribution point 40. Hence, no central MSC is required for routing. Distributed routing removes delays caused by central switching, increases the robustness of the communication system 20, increases 20 network efficiency, and permits simplified expansion or reduction of communication system 20 by automatically adding or removing distribution points 40.

A third option is that distribution point 40 determines that the information packet is destined for a destination not part of communication system 20. Special distribution points, such as gateway 50, provide a bridge to additional 25 communication systems 52 including wireless and wireline telecommunication systems, video distribution systems, computer network systems such as the Internet, packet systems, frame systems, ATM systems, IP systems, private networks, and any other suitable communication or information system. If distribution point 40 determines the information packet is destined for delivery outside of communication 30 system 20, distribution point 40 forwards the packet to one of distribution points 40 in communication with gateway 50.

5                   In an embodiment of the present invention, communication system 20 includes communication system interface device 54 operative to format information contained in the information packet to pass through telecommunication system 52. Communication system interface device 54 may be incorporated into gateway 50 or may be a separate component of communication system 20. Distribution point 40 receives at least one information packet from the telecommunication system interface device 54 and determines if the at least one information packet destination is to subscriber unit 26 within coverage area 24 of access point 22 in communication with distribution point 40. Distribution point 40 forwards the at least one information packet to access point 22 defining coverage area 24 containing subscriber unit 26 if the information packet destination is to subscriber unit 26 within coverage area 24 of access point 22 in communication with distribution point 40 and forwards the at least one information packet to one of the additional distribution points 40 in communication with distribution point 40 otherwise.

10

15                   Each distribution point 40 communicates with supervisor 56. Supervisor 56 tracks the locations of subscriber units 26 within communication system 20, identifying with which distribution point 40 each subscriber unit 26 is currently communicating. Supervisor 56 manages transmission priorities based on parameters including load, information type, service requests, location, grade of service, information transfer rates, or any other suitable parameter. Supervisor 56 may also serve as a collection point for alarms and performance measuring of communication system 20. Supervisor 56 may further include or interface with billing and authentication services.

20

25                   In an embodiment of the present invention, supervisor 56 also assigns an address to each distribution point 40 as distribution point 40 is added to communication system 20. Supervisor 56 provides each distribution point 40 with a logical address and a listing indicating to which additional distribution point 40 in communication with distribution point 40 information packets should be forwarded for each possible destination distribution point 40. The listing may be based on maintaining a minimum quality of service in the path through distribution point network 41 to the destination distribution point 40. Supervisor 56 periodically

30

assesses the performance of network 41 by sending test messages. Reports may also be generated by distribution points 40 attempting to communicate with target addresses.

5 Supervisor 56 is shown in Figure 1 as a separate component individually connected to each distribution point 40. Alternatively, communication between supervisor 56 and distribution points 40 may be through radio links 46 and wireline links 48. Supervisor 56 may be one or more separate components of communication system 20, may be incorporated into one of distribution points 40, or may be distributed amongst multiple distribution points 40.

10 In an embodiment of the present invention, a distribution point may be automatically added to or removed from distribution point network 41. When new distribution point 40 is first inserted into communication system 20, new distribution point 40 transmits a signature signal. Existing distribution points 40 within range of new distribution point 40 receive the signal and report it to 15 supervisor 56. Supervisor 56 then determines if new distribution point 40 will be added to network 41. If so, supervisor 56 assigns new distribution point 40 a routing address and informs network 41 as needed. Each existing distribution point 40 in distribution point network 41 is provided with an indication as to which 20 distribution point 40 in communication with existing distribution point 40 each information packet having a destination address specifying the new distribution point 40 is to be forwarded. If a distribution point 40 is removed from network 41, remaining distribution points 41 report the absence of removed distribution point 40 to supervisor 56. Supervisor 56 then informs network 41 as needed.

25 In an embodiment of the present invention, each subscriber unit 26 is autonomously registered with communication system 20 when subscriber unit 26 first enters coverage area 24 within communication system 20. Each subscriber unit 26 maintains registration as subscriber unit 26 moves from one coverage area 24 into another coverage area 24 within communication system 20 and is autonomously deregistered when subscriber unit 26 leaves communication system 20. To 30 accomplish automatic registration and deregistration of subscriber units 26, each

access point 22 periodically reports the status of subscriber units 26 within any controlled coverage area 24 to supervisor 56 performing registration and authentication. Each access point 22 communicates with subscriber units 26 to determine status. When a subscriber unit 26 voluntarily enters or leaves coverage 5 area 24, such as by powering up or down, subscriber unit 26 transmits a particular signal to access point 22. Information is also received from subscriber unit 26 in response to periodic queries from network 20. Access point 22 may determine the absence of subscriber unit 26 from coverage area 24 if no communication is received after a particular time interval. Algorithms for registering and deregistering 10 subscriber units 26 may be based on various factors including quality of service, traffic, location, service type, network topology, and the like.

Referring now to Figure 2, a block diagram of a distribution point according to an embodiment of the present invention is shown. Distribution point 40 includes one or more front end communication interfaces 100, each front end 15 interface communicating with one access point 22. In one configuration, access point 22 is packaged with distribution point 40. Front end interface 100 may provide a plug-in port for receiving access point 22. In another configuration, front end interface 100 connects to antenna 102 for establishing radio link 42 with access point 22. In a further configuration, front end interface 100 accepts wireline link 44 20 connecting distribution point 40 with access point 22. Front end interface 100 operates using a standard packet switching protocol such as, for example, ATM25. Each front end communication interface 100 passes information packets through common front end switch interface 104 operating under a packet protocol such as ATM, TCP/IP, 802.x, or the like.

25 Distribution point 40 also includes back end communication interfaces 106 for connecting distribution point 40 with additional distribution points 40, with supervisor 56, and, if distribution point 40 is a gateway 50, with telecommunication systems, private network systems, video distribution systems, the Internet, or the like. This may be typically referred to as back haul communication. In one 30 configuration of the present invention, back end interface 106 connects to antenna 108 for establishing radio link 46 with another distribution point 40. In another

configuration, back end interface 104 accepts wireline link 44 connecting distribution point 40 with another distribution point 40. In a preferred embodiment, back end interface 106 accepts modules 110 for interfacing through a variety of protocols and media such as ATM25, DS1, DS3, OC3, 1000Base-T, 100Base-T, and the like.

5 Each back end communication interface 106 passes information packets through common back end switch interface 112 operating under a packet protocol such as ATM, TCP/IP, or the like. In a preferred embodiment, distribution point 40 dynamically allocates bandwidth when the information packet is forwarded to one of the additional distribution points 40 in communication with distribution point 40.

10 Intelligent packet switch 114 received information packets through common front end switch interface 104 and common back end switch interface 112 and routes the packets between front end interfaces 100 and back end communication interfaces 106. Switch 114 may be a packet switching device as is known in the art such as an ATM switch, an IP switch, a TDM switch, a switch working under the 15 802.11 specification, or any other suitable alternative or combination having the required switching functionality. In an embodiment of the present invention, switch 114 includes an ATM portion for routing voice, video and data, and an IP portion for real-time dynamic data routing and non-real time data routing as well as administration, management, and network topology control.

20 In an embodiment of the present invention, distribution point 40 is enclosed in an environmentally sealed package. This permits distribution point 40 to be mounted outside, such as on a pole or the side of a building. In keeping with the invention, however, distribution point 40 need not be outside so long as it can communicate with access points 22, additional distribution points 40, supervisor 56, 25 and any other suitable network component.

30 Referring now to Figure 3, a schematic drawing illustrating an implementation of a communication system according to an embodiment of the present invention is shown. This implementation provides an example including interfaces between communication system 20 and a variety of external communication systems 52.

Communication system 20 includes wireless service location registers (WSLRs) 200 providing common subscriber and service databases. Each WSLR 200 communicates with at least one distribution point 40 and one additional communication system 52. Connections between WSLRs 200 and communication systems 52 are not shown in Figure 3 for clarity. Each WSLR 200 provisions requested services from additional communication system 52. For example, WSLR 200 may provide centralized mobility and location management. Supervisor 56 determines which WSLR 200 will provision services based on the distribution point 40 through which subscriber unit 26 requesting services is currently communicating.

5 A device that may serve as WSLR 200 is described in U.S. Patent No. 5,974,331 titled "Method And System For Dynamically Assigning Features And Users To Wireline Interfaces," to Cook *et al.* Call agents may also function as WSLR-like devices to map or integrate additional communication systems with system 20.

10

Communication system 20 may also include multi-service platform (MSP) 202. MSP 202 provides access to wireline telephone systems (PSTN). This may be accomplished through GR-303 compliant connection 204. Signaling point of interface (SPOI) 206 serves as the demarcation point between communication system 20 and external communication system 52. In the example shown, GR-303 connection 204 connects wireline provider 208, serving wired customers 210, with communication system 20. MSP 202 may integrate both PSTN and IP networks as well as provide enhanced circuit/packet switch services.

15

At least one gateway 212 supports MSP 202. Communication system 20 may include, for example, voice-over-ATM (VoATM) to GR-303 gateways and voice over IP (VoIP) to GR-303 gateways. Gateway 212 serves as a protocol agent, converting information packets to a format acceptable to additional communication system 52. A determination as to which gateway 212 will process an information packet may be based on information contained within the information packet. Gateways 212 may be connected to MSP 202 by GR-303 compliant connection 214.

25

Communication system 20 may also include gateway 216 connecting communication system 20 with external data network 52 such as the Internet or a

30

private data network interconnecting network users 218. Gateway 216 may, for example, convert between various packet-based standards such as H.323 and SIP.

Communication system 20 may also include gateway 220 interfacing communication system 20 with external SS7 network 52 represented by signal transfer point (STP) 222. Gateway 220 communicates with STP 222 through ISUP compliant connection 224 which permits setting up and taking down trunk calls, calling party information services, call status, and any other suitable network function, by passing signaling information through SS7 network 52 to wireline provider 208 under the control of integrated services control point (ISCP) 226.

Communication system 20 may also include unified message center (UMC) 228. Unified messages, also known as integrated messages, permit messages from a variety of sources such as telephone, email, fax, reports, compound documents, or any other suitable information or communication device, to be summarized and presented on a single medium, such as a personal computer. Messages may even be translated from one media type to another. UMC 228 supports unified message applications within communication system 20. In an embodiment, UMC 228 communicates with wireline provider 208, permitting greater integration, flexibility and access to messages.

Connection controller 230 controls access to gateways 50, 202, 212, 216, 220, or any other suitable interface. For example, connection controller 230 may manage voice over ATM to GR-303 access, voice over IP to GR-303 access, H.323/SIP to Internet remote access, SS7 to IP access, and the like. Connection controller 230 may also support information rate adaptation including open application processor interfaces and robust application development platforms.

Referring now to Figures 4-6, drawings illustrating dynamic growth of a distribution point network according to an embodiment of the present invention are shown. An initial configuration for system 20 is shown in Figure 4. ATM/IP switch 300 is in communication with supervisor 56 through ATM virtual connection 302. In this simple configuration, ATM/IP switch 300 may be functioning as access

point 22. ATM/IP switch 300 may obtain an IP address and an ATM address either manually or automatically.

ATM/IP switch 300 automatically requests addresses by first broadcasting an ATM request in an IP packet over virtual connection (VC) 302. 5 Supervisor 56 forwards this request to address server 304. Address server 304 responds by allocating unique ATM end system addresses (AESAs) 306 to the address assignment client in ATM/IP switch 300, which updates the ATM layer with new address 306. The address assignment client in ATM/IP switch 300 next requests from address server 304 an IP address, again using IP as the transport service over 10 pre-existing ATM VC 302. Address server 304 forwards IP address 308 to ATM/IP switch 300. ATM/IP switch 300 then requests address pools for ATM and IP. Address server 304 responds by supplying AESA pool 310 and IP address pool 312. Pools of addresses 310, 312 are used by switch 300 when functioning as distribution point 40 in support of other distribution points 40 and access points 22.

15 Referring now to Figure 5, a drawing illustrating the addition of a second access point is shown. Access point 22 has the capability to function as a distribution point 40. As new access points 22 are subtended from an existing access point 22, existing access point 22 becomes a distribution point 40. Each distribution point 40 continues to communicate with its initially connected distribution point 40 and with other distribution points 40 as they are provisioned. As new links 46, 48 20 between distribution points are created, distribution points 40 form peer relationships at both the ATM layer and the IP layer. Distribution points 40 are always peers at the IP and ATM layer, while access points 22 are clients of distribution points 40. As such, each ATM/IP switch 300 functions as a server when operating as 25 distribution point 40 and as a client when operating as access point 22.

When new ATM/IP switch 320 is instantiated as access point 22, it 30 will automatically request an ATM address in an IP packet address assignment request. This IP packet will be sent in an ATM frame over radio link 46 to IP/ATM switch 300 functioning as distribution point 40 using a pre-existing ATM VC. IP/ATM switch 300 will allocate unique ATM address 322 from AESA pool 310 and

unique IP address 324 from IP address pool 312. ATM/IP switch 320 then sends a directed request to address server 304 and receives its own AESA pool 326 and IP address pool 328.

Referring now to Figure 6, a hierarchical routing network is shown.

5 Address server 304 assigns AESA pool 310 and IP address pool 312 as each ATM/IP switch 300 is added. By handling all requests for address pools 310, 312, address server 304 maintains a hierarchy of addresses for both ATM and IP layers. Address server 304 constructs routing tables for each ATM/IP switch 300 indicating to which directly connected ATM/IP switch 300 each incoming packet should be  
10 routed if the packet is not destined to subscriber unit 26 serviced by that ATM/IP switch 300. Thus, routing tables are cohesive, reflecting the view of communication system 20 seen by each ATM/IP switch 300. Address server 304 also constructs forward equivalency class (FEC) tables permitting ATM/IP switch 300 to route packages based on package contents. FECs can be seen as either the virtual path  
15 identifier (VPI) portion of the ATM VPI/VCI or as the entire VPI/VCI, and are enabled by the routing protocols at the IP and PNNI layers.

New routing elements are dynamically added to a network of routing elements by establishing a connection between the new routing element and an existing routing element in the network of routing elements. At least one address  
20 is assigned to the new routing element, each assigned address coming from a pool of addresses maintained at the existing routing element. At least one pool of addresses is issued to the new routing element. The one or more pool of addresses permitting the new routing element to dynamically add yet another new routing element to the network of routing elements.

25 In an embodiment of the present invention, a method of dynamically adding a routing element to a distributed communications includes establishing an ATM virtual connection with an existing distribution point already part of the communications network. An ATM end user address is requested from the existing distribution point. An ATM end user address is obtained from the existing  
30 distribution point, the ATM end user address allocated from a pool of ATM end user

addresses in the existing distribution point. An IP address is requested from the existing distribution point. An IP address is obtained from the existing distribution point, the IP address allocated from a pool of IP addresses in the existing distribution point. Preferably, a pool of ATM end user addresses is requested and received from an address server. A pool of IP addresses is requested and received from the address server. An ATM end user address from the pool of ATM end user addresses and an IP address from the pool of IP addresses may be assigned to a new routing element requesting to be added to the communications network.

In an embodiment of the present invention, when a new distribution point is added to a network of distribution points, a connection is established between the new distribution point and at least one existing distribution point in the network of distribution points. A peer-to-peer relationship is formed at the OSI network layer between the new distribution point and the at least one existing distribution point. A peer-to-peer relationship is formed at the OSI data link layer between the new distribution point and the at least one existing distribution point.

In an embodiment of the present invention, when an access point is added to a network of distribution points, a connection is established between the access point and at least one existing distribution point in the network of distribution points. A client-server relationship is formed at the OSI network layer between the access point client and the at least one existing distribution point server. A client-server relationship is formed at the OSI data link layer between the access point and the at least one existing distribution point server.

In an embodiment of the present invention, when an ATM/IP switch 300 is removed from communication system 20, all of the addresses 306, 308 and address pools 310, 312 associated with the removed switch 300 are released. Addresses 306, 308 and address pools 310, 312 may be instantiated at distribution point 40 which originally supplied removed switch 300 with addresses 306, 308, may be sent to supervisor 56, or may be split with addresses 306, 308 returning to distribution point 40 and address pools 310, 312 returning to supervisor 56.

When subscriber unit 26 first enters communication system 20, it is detected and serviced by access point 22. Subscriber unit 26 is provided with one or more addresses, each address routable within at least the local hierarchy of ATM/IP switches 300. If subscriber unit 26 enters the range of a new access point 5 22, new access point 22 sends out a flooding FEC routing update for the ATM address of subscriber unit 26. Previously servicing access point 22 removes subscriber unit 26 from its own FEC upon receiving the FEC update. Any subsequent ATM packets received by previously servicing access point 22 are discarded.

10 When subscriber unit 26 changes access points 22, the IP routing portion of system 20 moves the IP address of subscriber unit 26 from one FEC class to another. Any IP packets remain untouched, with only a label or equivalence changed. In one embodiment, the label is the VPI portion of the VC. In another embodiment, multiprotocol label switching (MPLS) is used to provide an additional 15 label. In either case, the IP address and virtual connection identifier (VCI) are retained.

20 Referring now to Figure 7, a schematic drawing illustrating a network of distribution points routing packets based on forwarding equivalency classes is shown. Each distribution point contains an FEC table 400 used to route packets received from and destined to subscriber units 26. Forwarding equivalency class table 400 contains one entry for each forwarding equivalency class 402. In the embodiment shown, there is one FEC 402 corresponding to each access point 22. When subscriber unit 26 is first detected by access point 22, the address for 25 subscriber unit 22 is placed in the equivalency class 402 corresponding to the detecting access point 22. The address is typically an IP address. This may be done by broadcasting from detecting access point 22 or, preferably, is done by supervisor 56 after supervisor 56 receives a message indicating subscriber unit 26 has been detected by access point 22.

30 FEC table 400 in each distribution point 40 contains the next destination for each FEC 402. Typically, destinations are other distribution points

40, access points 22 serviced by distribution point 40, gateways 50, and other suitable points for routing, switching, servicing, distributing, and the like. When a packet destined for subscriber unit 26 is received by distribution point 40, distribution point 40 determines to which FEC subscriber unit 26 is assigned, 5 determines to which destination the packets in that FEC are routed, and forwards the packet to the determined destination.

Referring now to Figure 8, a schematic drawing illustrating forwarding equivalency class updating to track a moving subscriber unit is shown. If subscriber unit 26 is mobile or portable, as indicated by U1 in Figure 8, 10 subscriber unit 26 may move out of coverage area 24 for one access point 22 and into coverage area 24 for a new access point 22. The address for subscriber unit 26 is then moved from FEC 402 of original access point 22 into FEC 402 for new access point 22. In an embodiment, when original access point 22 is no longer in communication with subscriber unit 26, original access point 22 broadcasts a 15 message to distribution points 40 and supervisor 56. If original access point 22 subsequently receives any packets for subscriber unit 26, original access point forwards these packets back into distribution point network 41. If the packets are sequentially indicated, such as IP packets, correct order will be established by subscriber unit 26 when packets are received.

20 While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

**WHAT IS CLAIMED IS:**

- 1                   1. A method of dynamically adding a new routing element to a  
2 network of routing elements comprising:
  - 3                   establishing a connection between the new routing element and an  
4 existing routing element in the network of routing elements;
  - 5                   assigning at least one address to the new routing element, each  
6 assigned address coming from a pool of addresses maintained at the existing routing  
7 element; and
  - 8                   issuing at least one pool of addresses to the new routing element, the  
9 at least one pool of addresses permitting the new routing element to dynamically add  
10 yet another new routing element to the network of routing elements.
- 1                   2. A method of dynamically adding a new routing element as in  
2 claim 1 further comprising placing an address for each subscriber unit accessing the  
3 network of routing elements into at least one forward equivalency class based on the  
4 at least one assigned address.
- 1                   3. A method of dynamically adding a new routing element as in  
2 claim 1 further comprising:
  - 3                   determining that the new routing element is no longer connected to  
4 an existing routing element in the network of routing elements;
  - 5                   releasing the at least one address assigned to the new routing element;
  - 6                   and
  - 7                   releasing the at least one pool of addresses issued to the new routing  
8 element
- 1                   4. A method of dynamically adding a new routing element as in  
2 claim 1 wherein establishing a connection between the new routing element and an  
3 existing routing element in the network of routing elements comprises establishing  
4 an ATM virtual connection with an existing distribution point already part of the  
5 communications network.

- 1                   5.        A method of dynamically adding a new routing element as in
- 2        claim 1 wherein assigning at least one address to the new routing element comprises:
- 3                   requesting an ATM end user address from the existing distribution
- 4        point;
- 5                   obtaining an ATM end user address from the existing distribution
- 6        point, the ATM end user address allocated from a pool of ATM end user addresses
- 7        in the existing distribution point;
- 8                   requesting an IP address from the existing distribution point; and
- 9                   obtaining an IP address from the existing distribution point, the IP
- 10      address allocated from a pool of IP addresses in the existing distribution point.

1                   6.        A method of dynamically adding a new routing element as in  
2 claim 5 wherein issuing at least one pool of addresses comprises:  
3                   requesting a pool of ATM end user addresses from an address server;  
4                   receiving a pool of ATM end user addresses from the address server;  
5                   requesting a pool of IP addresses from the address server; and  
6                   receiving a pool of IP addresses from the address server.

1                   7.        A method of dynamically adding a new routing element as in  
2        claim 1 wherein the new routing element is a distribution point.

1                    8.        A method of dynamically adding a new routing element as in  
2 claim 7 further comprising:  
3                    forming a peer relationship with at least one existing distribution point  
4 at the data link layer for voice communication; and  
5                    forming a peer relationship with the existing distribution point at the  
6 network layer for data communication.

1                   10.     A method of dynamically adding a new routing element as in  
2     claim 9 wherein the access point is a local radio access point serving a plurality of  
3     packet radios.

1                   11.     A method of dynamically adding a new routing element as in  
2     claim 9 further comprising:

3                   forming a client relationship at the data link layer with at least one  
4     existing distribution point, the existing distribution point functioning as a server for  
5     voice communication; and

6                   forming a client relationship at the network layer with the existing  
7     distribution point, the existing distribution point functioning as a server for data  
8     communication.

1                   12.     A method of dynamically adding a new routing element as in  
2     claim 11 further comprising:

3                   adding at least one additional access point as a client;

4                   forming a peer relationship with communicating existing distribution  
5     points at the data link layer for voice communication; and

6                   forming a peer relationship with communicating existing distribution  
7     points at the network layer for data communication.

1                   13.     A method of routing information packets in a distributed  
2     routing network comprising:

3                   determining a forwarding equivalency class for each subscriber unit  
4     accessing the network based on a point at which the subscriber unit accesses the  
5     network;

6                   updating the forwarding equivalency class for each subscriber unit if  
7     the subscriber unit accesses the network at a different point; and

8                   determining a next distribution element to forward an information  
9     packet based on the forwarding equivalency class for a destination subscriber unit.

1                   14.     A method of routing information packets in a distributed  
2     routing network as in claim 13 further comprising distributing the forwarding

3        equivalency class for each subscriber unit to each distribution element in the  
4        distributed routing network.

1            15. A method of routing information packets in a distributed  
2        routing network as in claim 13, the distributed routing network including a plurality  
3        of distribution points, each distribution point in direct communication with at least  
4        one additional distribution point in the network of distribution points, the distributed  
5        routing network also including an assigned access point for each subscriber unit  
6        accessing the communication system, the access point in communication with at least  
7        one distribution point in the network of distribution points, wherein determining a  
8        forwarding equivalency class is based on the access point.

1            16. A method of routing information packets in a distributed  
2        routing network as in claim 15 further comprising distributing the equivalency class  
3        to each distribution point.

1            17. A method of routing information packets as in claim 15 further  
2        comprising placing an IP address for each subscriber unit in the determined  
3        forwarding equivalency class.

1            18. A method of routing information packets as in claim 15 further  
2        comprising:  
3                determining that a subscriber unit should be assigned to a different  
4        access point;  
5                determining a new access point for the subscriber unit;  
6                determining a forwarding equivalency class for the subscriber unit  
7        based on the new access point; and  
8                notifying each distribution point in the network of distribution points  
9        of the forwarding equivalency class.

1            19. A method of routing information packets as in claim 18  
2        wherein determining a new access point for the subscriber unit comprises

3 transmitting an indication for the new access point through the network of  
4 distribution points.

1 20. A method of routing information packets as in claim 18 further  
2 comprising:

3 determining that the subscriber unit is no longer accessing the network  
4 through an access point; and

5 broadcasting an indication for the access point through the network  
6 of distribution points.

1 21. A method of routing information packets as in claim 18  
2 wherein determining a forwarding equivalency class for the subscriber unit  
3 comprises:

4 receiving a determination that the subscriber unit is accessing the  
5 network through an access point; and

6 broadcasting the assignment of the forwarding equivalency class to  
7 each distribution point in the network of distribution points.

1 22. A method of routing information packets as in claim 21  
2 wherein receiving is at a supervisor and broadcasting is from the supervisor.

1 23. A communication system comprising:

2 a network of distribution elements, each distribution element sending  
3 information packets to at least one additional distribution element, each distribution  
4 element maintaining at least one pool of addresses; and

5 a new distribution element joining the network of distribution  
6 elements, the new distribution element operative to

7 (a) establish a connection to an existing distribution element in  
8 the network of distribution elements;

9 (b) receive at least one address from the existing distribution  
10 element, each received address coming from a pool of  
11 addresses maintained by the existing distribution element; and

12 (c) receive at least one pool of addresses, each pool of addresses  
13 permitting the new distribution element to dynamically add  
14 yet another new distribution element to the network of  
15 distribution elements.

1 24. A communication system as in claim 23 wherein the received  
2 address comprises at least one from a set including an ATM address and an IP  
3 address.

1 25. A communication system as in claim 23 wherein the at least  
2 one received address comprises an ATM address and an IP address.

1 26. A communication system as in claim 23 wherein the  
2 established connection is a wireline connection.

1 27. A communication system as in claim 23 wherein the  
2 established connection is a wireless connection.

1 28. A communication system as in claim 23 wherein the new  
2 distribution element further receives at least one forward equivalency class for  
3 routing information packets.

1 29. A communication system as in claim 23 wherein the network  
2 of distribution elements is operative to:  
3 determine that the new distribution element is no longer connected to  
4 any existing distribution element in the network of distribution elements;  
5 recover the at least one address received from the existing distribution  
6 element; and  
7 recover the at least one pool of addresses.

1 30. A communication system as in claim 23 wherein the network  
2 of distribution elements comprises:

3                   a supervisor operative to supply a plurality of pools of ATM end user  
4                   addresses and a plurality of pools of IP addresses;  
5                   a plurality of access points, each access point operative to transmit  
6                   packets to and receive packets from at least one subscriber unit; and  
7                   a plurality of distribution points, each distribution point in  
8                   communication with at least one other distribution point and with the supervisor,  
9                   each access point in communication with at least one distribution point.

1                   31. A communication system as in claim 30 wherein the new  
2                   distribution element is a new distribution point.

1                   32. A communication system as in claim 31 wherein the new  
2                   distribution element is operative to  
3                   (a) form a peer-to-peer relationship at the OSI network layer with  
4                   the at least one existing distribution point, and  
5                   (b) form a peer-to-peer relationship at the OSI data link layer  
6                   with the at least one existing distribution point.

1                   33. A communication system as in claim 32 wherein the peer-to-  
2                   peer relationship at the network layer governs exchanges of IP packets carrying data  
3                   and control information and wherein the peer-to-peer relationship at the data link  
4                   layer governs exchanges of ATM packets carrying voice information.

1                   34. A communication system as in claim 30 wherein the new  
2                   distribution element is a new access point.

1                   35. A communication system as in claim 34 wherein the new  
2                   distribution element is operative to  
3                   (a) form a client-server relationship at the data link layer with the  
4                   at least one existing distribution point, the new access point  
5                   functioning as a client and the at least one existing distribution  
6                   point functioning as a server, and

7 (b) form a client-server relationship at the network layer with the  
8 at least one existing distribution point, the new access point  
9 functioning as a client and the at least one existing distribution  
10 point functioning as a server.

1                   36. A communication system as in claim 35 wherein the client-  
2 server relationship at the network layer governs exchanges of IP packets carrying  
3 data and control information and wherein the client-server relationship at the data  
4 link layer governs exchanges of ATM packets carrying voice information.

37. A communication system for distributing packetized information comprising:

3 a plurality of access points, each access point operative to transmit  
4 packets to and receive packets from at least one subscriber unit accessing the  
5 communication system through the access point; and

6 a plurality of distribution points, the access points and distribution  
7 points forming a distributed network, each distribution point in communication with  
8 at least one other distribution point, each access point in communication with at least  
9 one distribution point, each distribution point routing information packets received  
10 by the distribution point based on a forwarding equivalency class for a recipient  
11 subscriber unit specified in the information packet.

1                   41. A communication system as in claim 37 wherein the  
2 forwarding equivalency class for a recipient user is determined based on the access  
3 point through which the recipient user is accessing the communication system.

1                   42. A communication system as in claim 37 wherein routing an  
2 information packet is based on an IP address within the information packet.

1                   43. A communication system as in claim 37 wherein each  
2 distribution point is further operative to change the forwarding equivalency class for  
3 a subscriber unit.

1                   44. A communication system as in claim 43 wherein the change  
2 in the forwarding equivalency class is based on a determination that the subscriber  
3 unit is accessing the communication system through a second access point different  
4 than a first access point through which the subscriber unit accessed the  
5 communication network.

1                   45. A communication system as in claim 44 wherein each  
2 distribution point is further operative to transmit an indication for the second access  
3 point.

1                   46. A communication system as in claim 44 wherein the subscriber  
2 unit is no longer accessing the communication system through the first access point,  
3 each distribution point further operative to transmit an indication of the first access  
4 point.

1                   47. A communication system as in claim 37 further comprising a  
2 supervisor operative to receive a determination that a subscriber unit is accessing the  
3 communication system through a second access point and to broadcast the  
4 assignment of a new forwarding equivalency class based on the second access point  
5 to the plurality of distribution points.

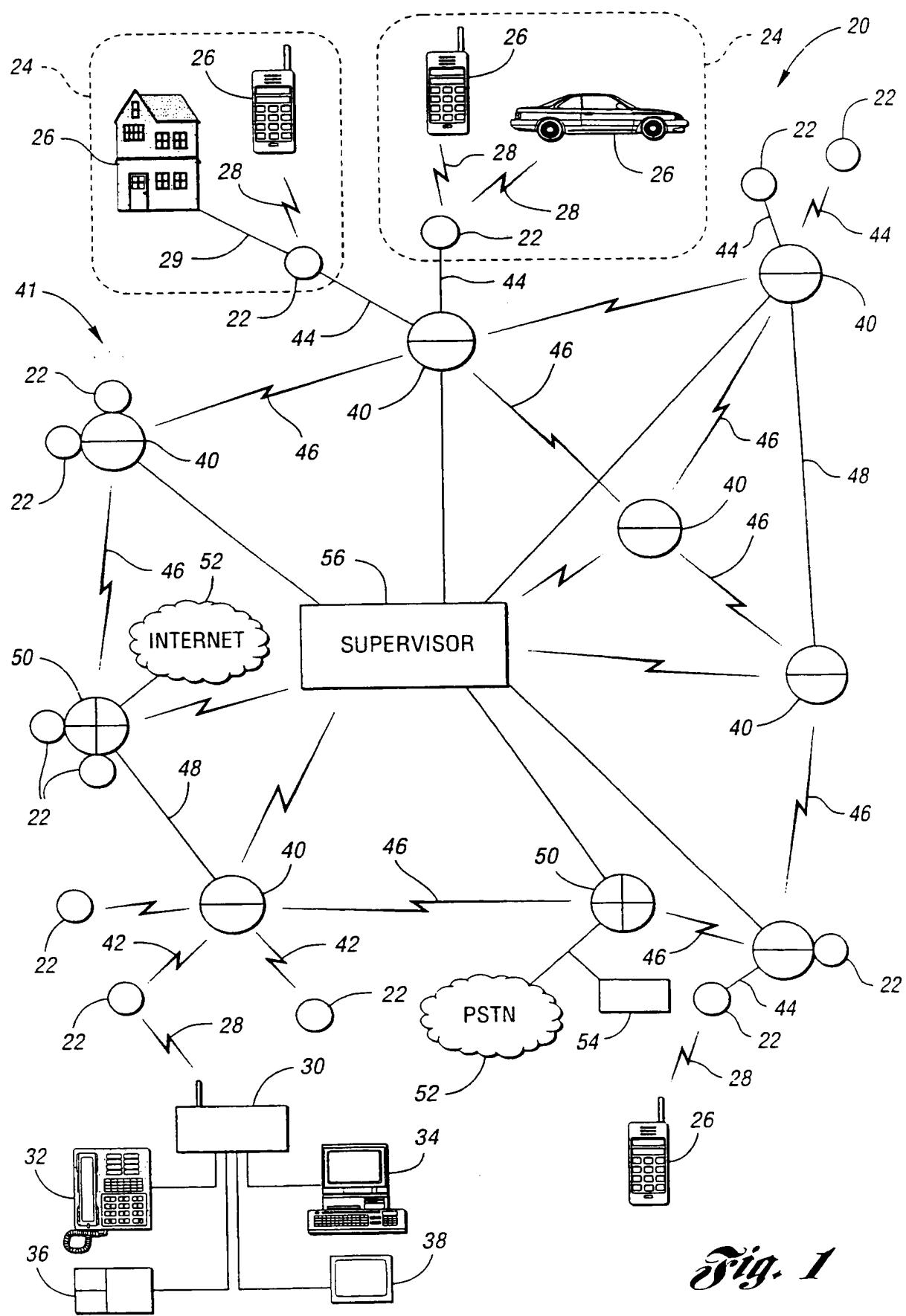
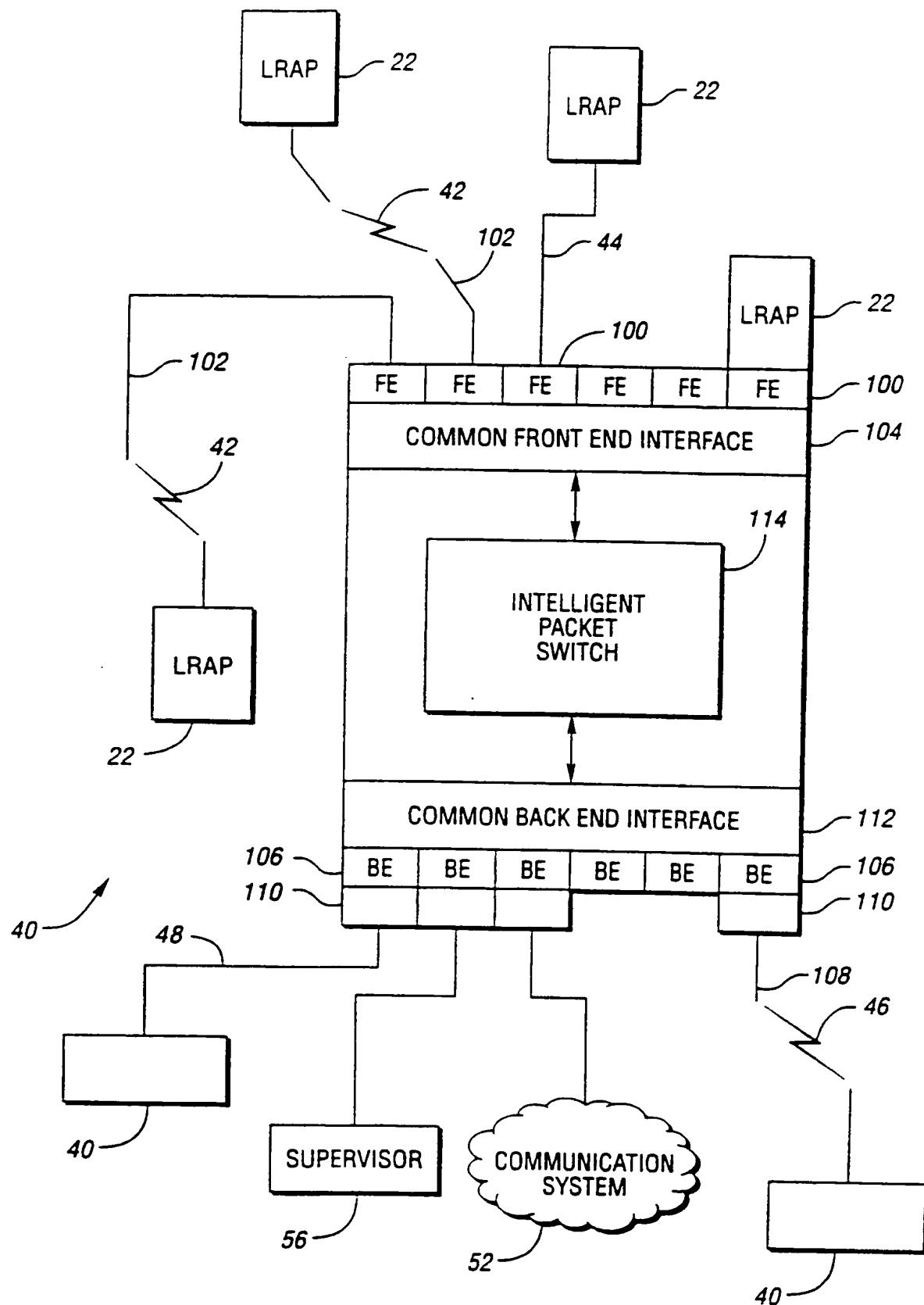
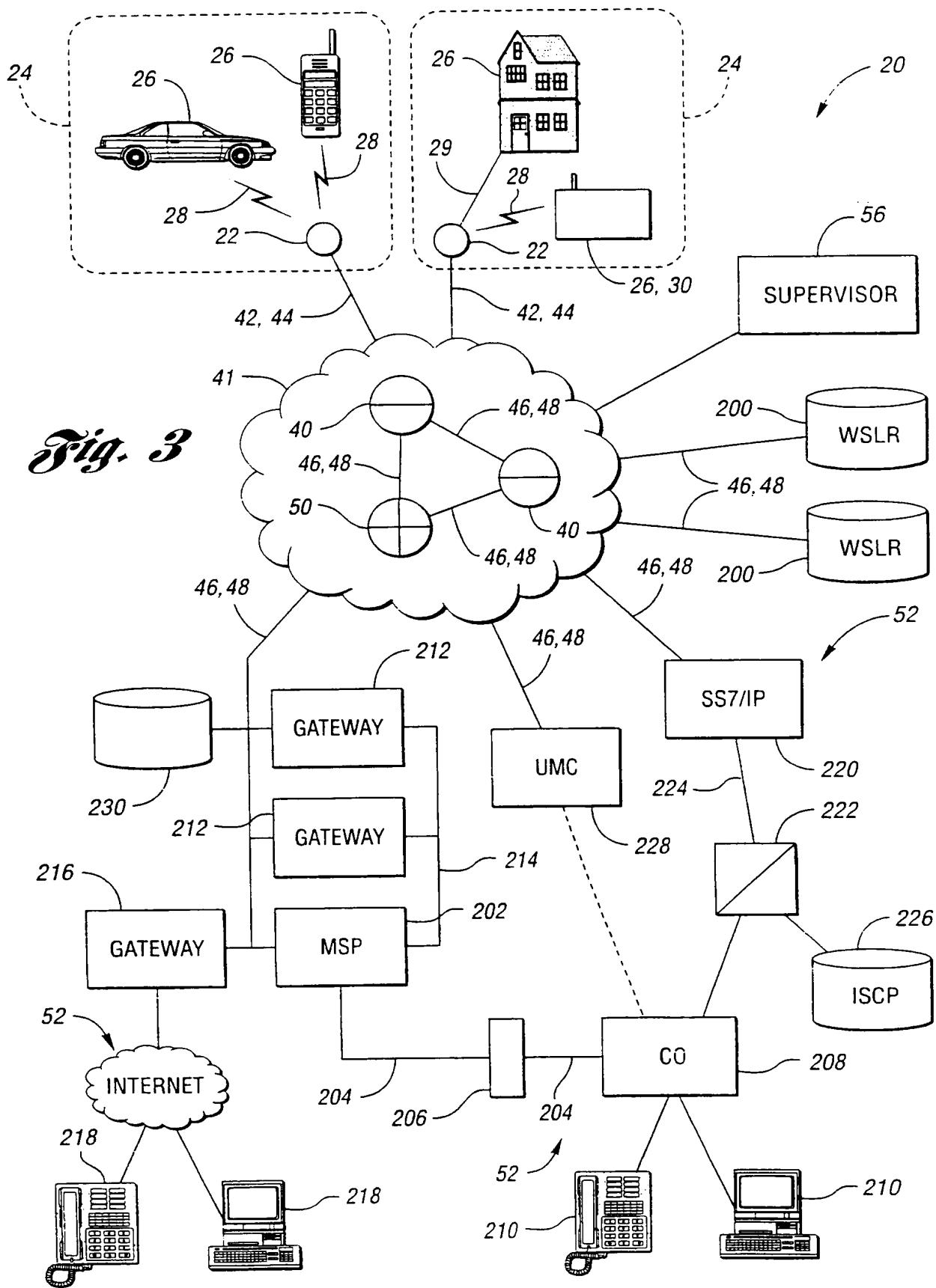
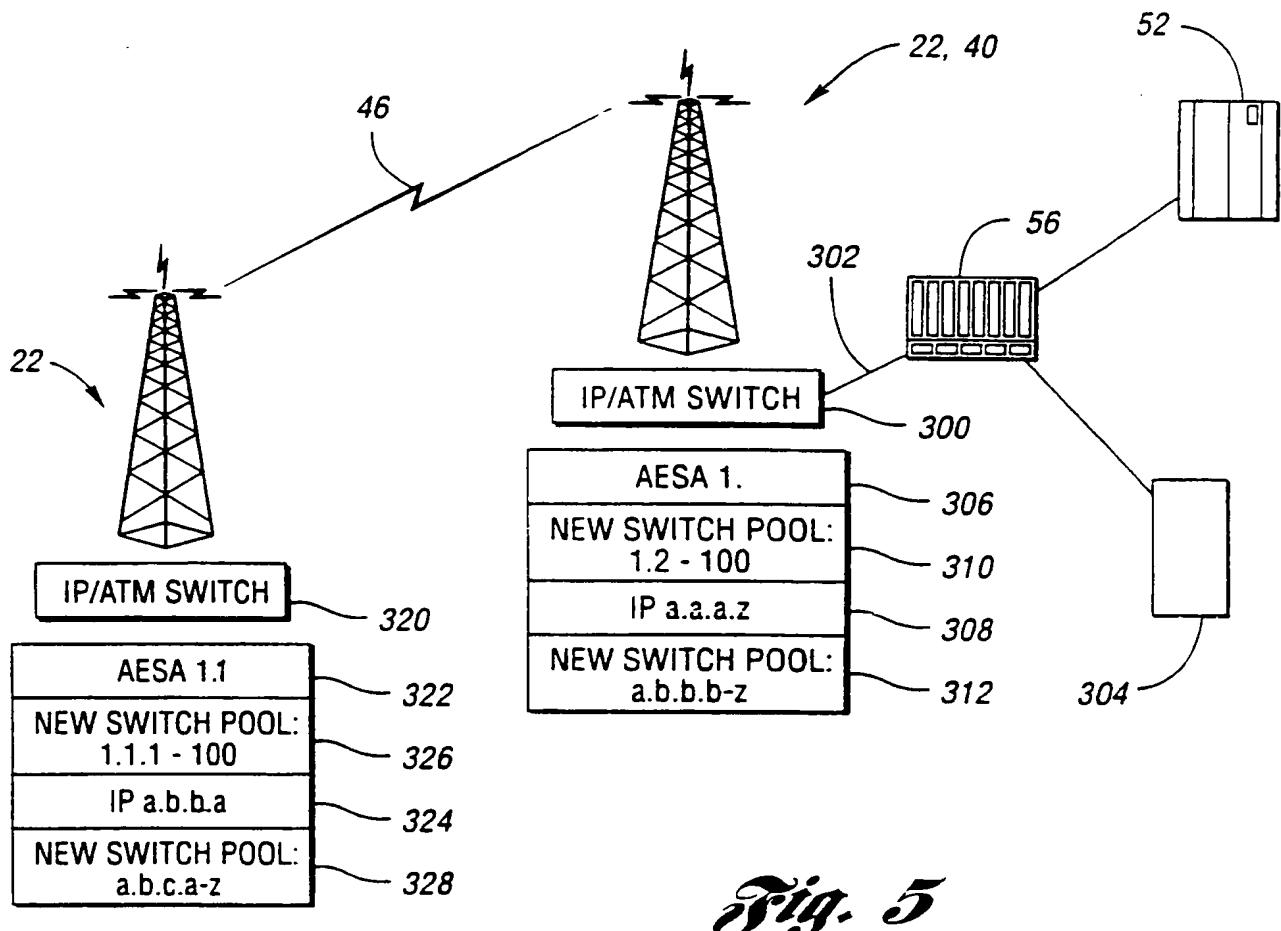
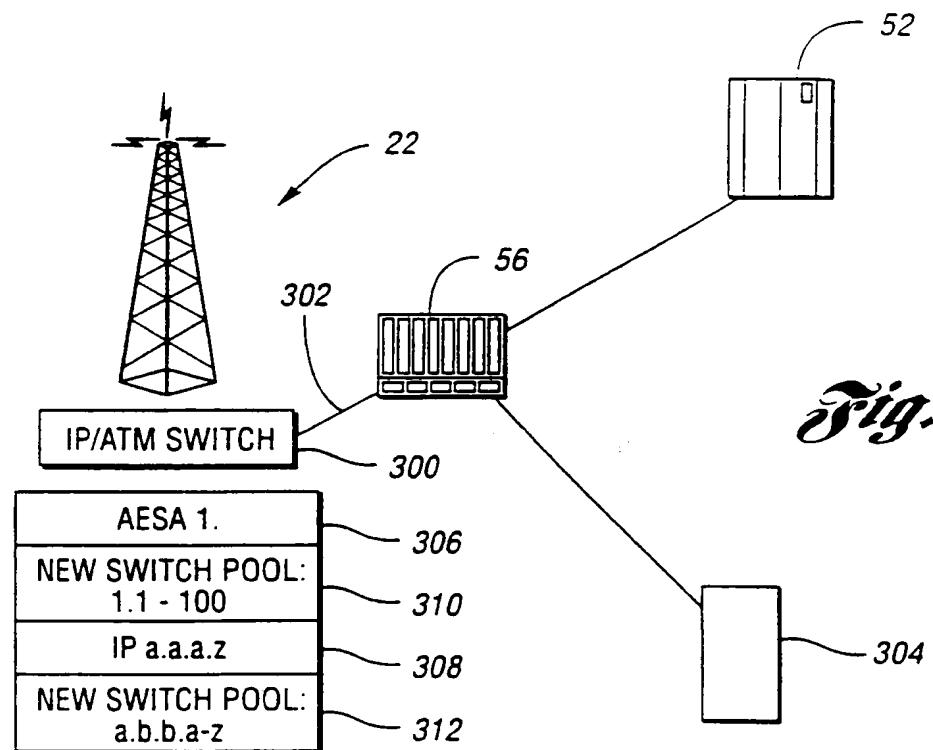


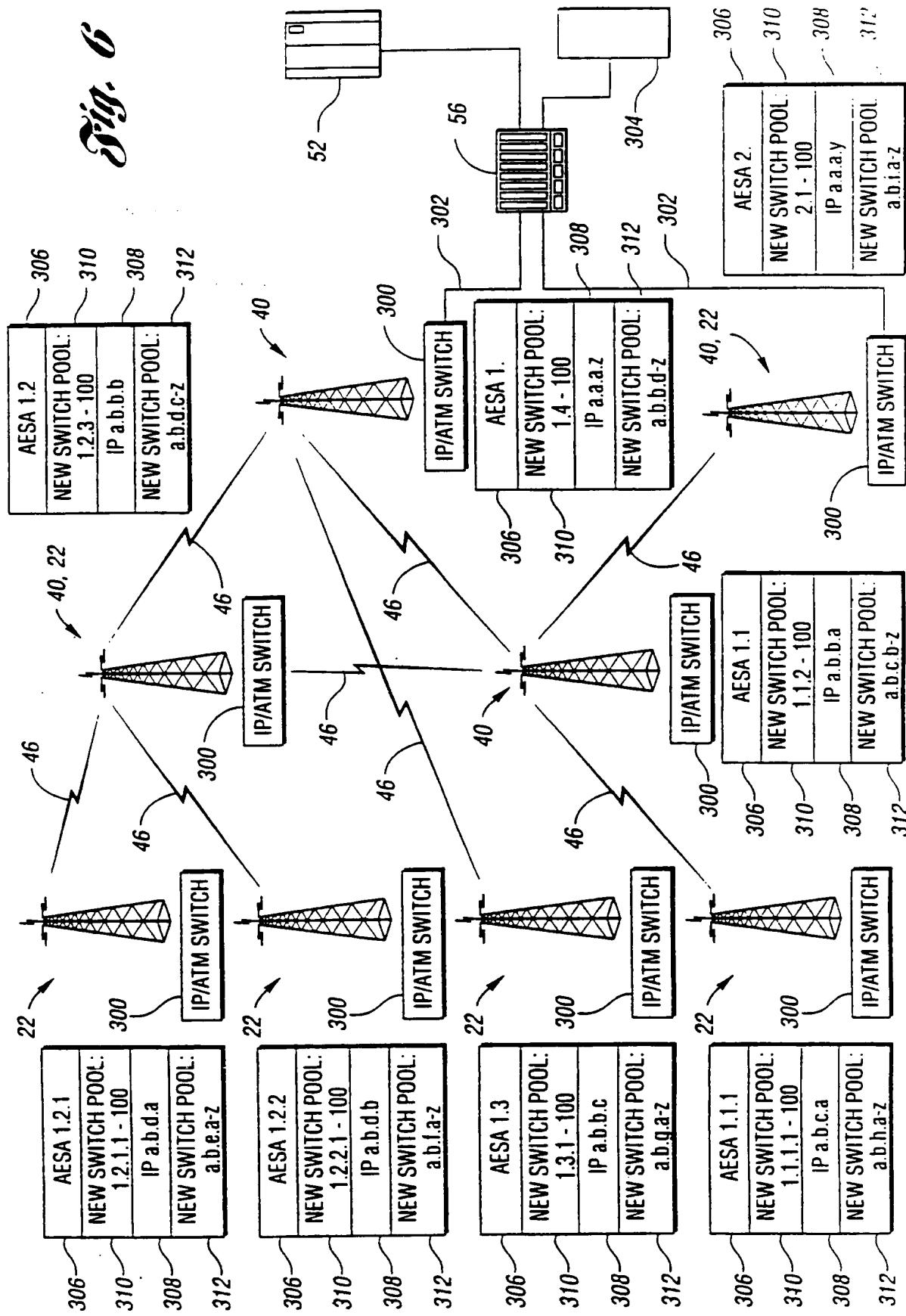
Fig. 1



*Fig. 2*







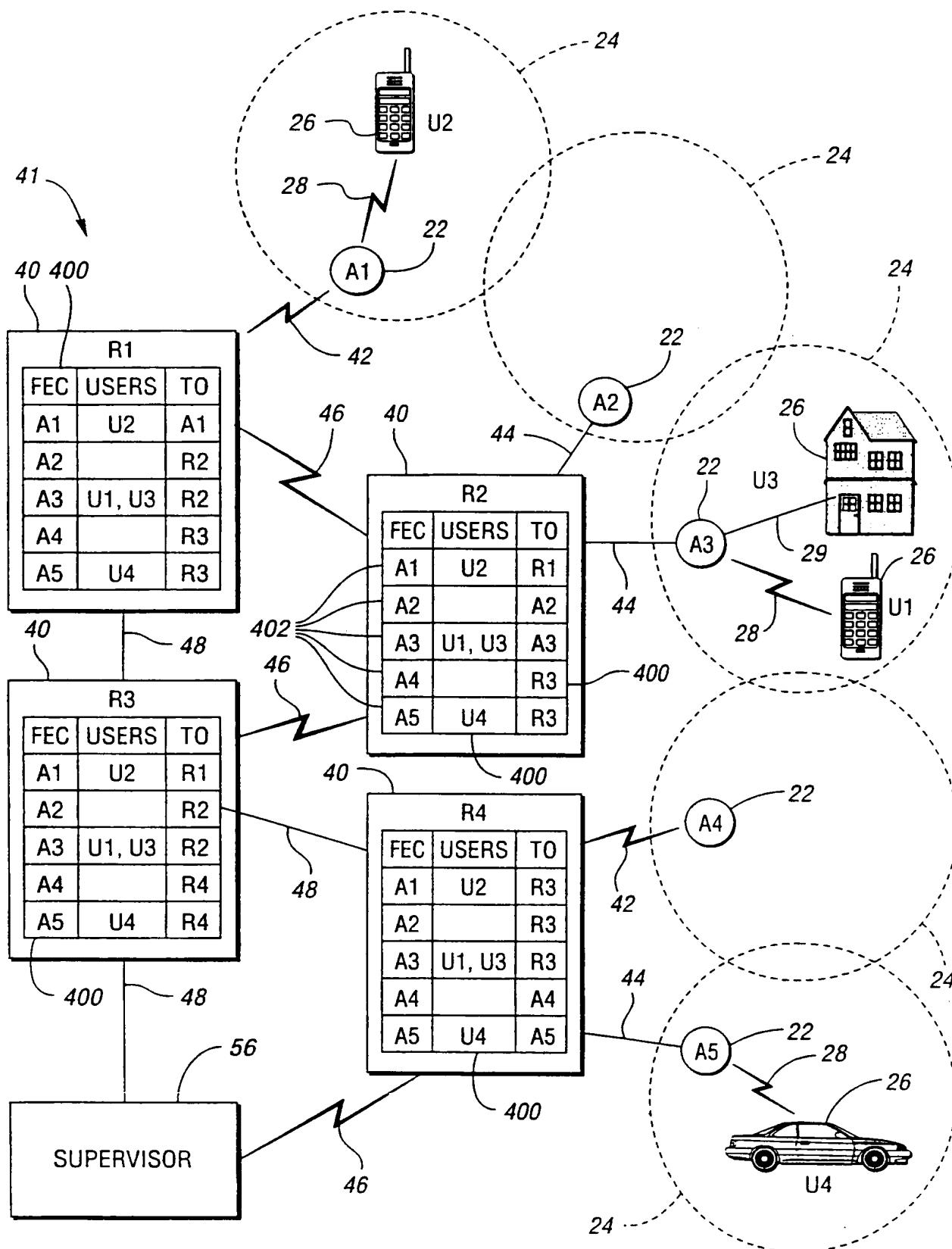


Fig. 7

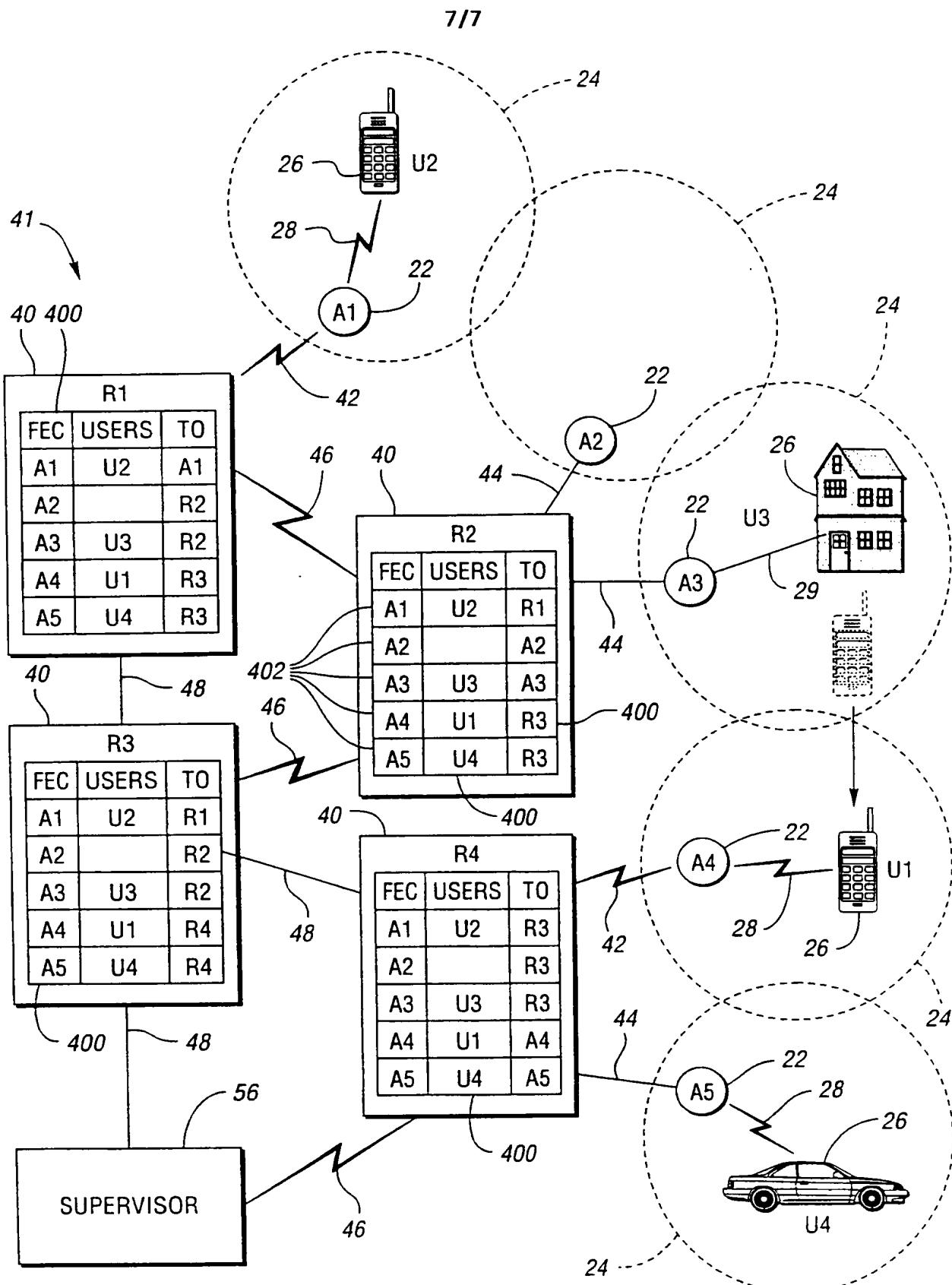


Fig. 8

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number  
WO 01/19025 A3

(51) International Patent Classification<sup>7</sup>: H04L 12/56. (29/06)

(21) International Application Number: PCT/US00/24510

(22) International Filing Date: 6 September 2000 (06.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/152,730	8 September 1999 (08.09.1999)	US
09/505,271	16 February 2000 (16.02.2000)	US
60/185,788	29 February 2000 (29.02.2000)	US
09/603,035	23 June 2000 (23.06.2000)	US
09/603,123	23 June 2000 (23.06.2000)	US

(72) Inventors: DOUGHERTY, Angus, O.: 11281 Ranch Place, Westminster, CO 80234 (US). HOHNSTEIN, Donald, L.: 2721 19th street, Greeley, CO 80634 (US). COOK, Charles, L.: 182 Cherrywood Lane, Louisville, CO 80027 (US). WELLS, Guy, M.: 480 West Street, Louisville, CO 80027 (US).

(74) Agents: CHUEY, Mark, D. et al.: Brooks & Kushman, Twenty-Second Floor, 1000 Town Center, Southfield, MI 48075 (US).

(81) Designated States (national): CA, KR, MX.

(84) Designated States (regional): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

(71) Applicant: QWEST COMMUNICATIONS INTERNATIONAL INC. [US/US]; 1801 California Street, 38th floor, Denver, CO 80202 (US).

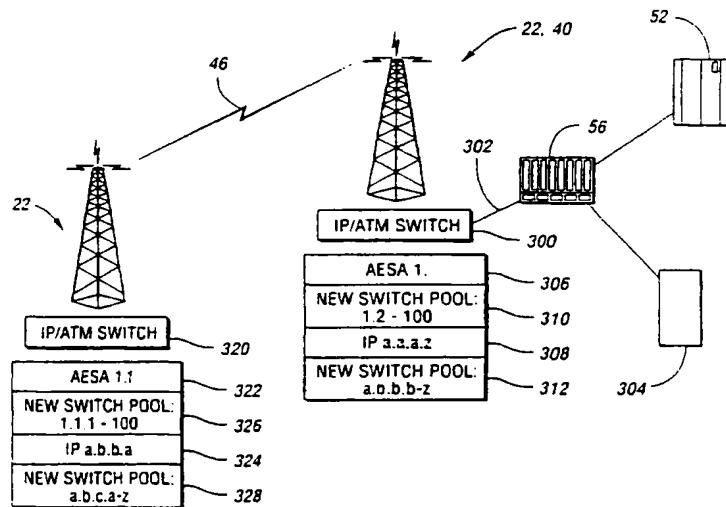
Published:

— with international search report

(88) Date of publication of the international search report: 24 January 2002

/Continued on next page/

(54) Title: SYSTEM AND METHOD FOR DYNAMIC DISTRIBUTED COMMUNICATION



WO 01/19025 A3

(57) Abstract: Growth of a distributed communication system (20) is facilitated through dynamic addition of distribution elements (22, 40, 50). A new element may be added to a network of elements by first establishing a connection (42, 44, 46, 48) between the new element and an existing element in the network. At least one address (322, 324) is assigned to the new element from a pool of addresses (310, 312) maintained at the existing element. At least one pool of addresses (326, 328) is issued to the new element, permitting the new element to dynamically add another new element. Information packets are routed through the network by determining a forwarding equivalency class (FEC) (400) for each subscriber unit (26) accessing the network. The FEC to which each subscriber unit belongs is based on the point (22) at which the subscriber unit accesses the network. Information packets are routed from a distribution element (40, 50) by determining the next element (22, 40, 50) based on the FEC for the destination subscriber unit.



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/24510

**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC 7 H04L12/56 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 26548 A (WHISTLE COMMUNICATIONS CORP ;COBBS ARCHIE L (US); LI JIM Y (US); 0) 18 June 1998 (1998-06-18) abstract page 2, paragraph 3	1,7,9, 23,26
Y	page 8, paragraph 3 page 9, paragraph 1	3,4,24, 29
A	page 14, paragraph 3 figures 2-4	8,10-12, 27
	---	---/---

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority, claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*&\* document member of the same patent family

Date of the actual completion of the international search

10 July 2001

Date of mailing of the international search report

30.07.2001

Name and mailing address of the ISA  
 European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
 Fax: (+31-70) 340-3016

Authorized officer

Blanco Cardona, P

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/24510

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DROMS R: "AUTOMATED CONFIGURATION OF TCP/IP WITH DHCP" IEEE INTERNET COMPUTING, US, IEEE SERVICE CENTER, PISCATAWAY, NJ, vol. 3, no. 4, 1999, pages 45-53, XP000874503 ISSN: 1089-7801 page 45, paragraph 5 -page 46, left-hand column, paragraph 3 ---	3, 29
X	WO 97 36405 A (NOKIA TELECOMMUNICATIONS OY ;HUUSKO SAMI (FI); KARI HANNU H (FI)) 2 October 1997 (1997-10-02) abstract page 4, line 12 -page 5, line 25	37, 42
A	page 7, line 16 - line 19; figure 1 ---	2, 13-22, 28, 38-41, 43-47
A	UKIAHSOFT: "NetRoad TrafficWare Eliminates Anarchy at the Internet Access Point and Improves Performance" NETROAD TRAFFICWARE, 'Online! December 1997 (1997-12), XP002116229 Retrieved from the Internet: <URL: <a href="http://www.ukiahsoft.com/trafficsds.pdf">http://www.ukiahsoft.com/trafficsds.pdf</a> > 'retrieved on 1999-09-22! the whole document ---	13, 41
Y	WO 97 48210 A (BELL COMMUNICATIONS RES) 18 December 1997 (1997-12-18) abstract page 3, paragraph 2 - paragraph 3 page 5, paragraph 4 -page 6, paragraph 3 page 7, line 30 - line 34	4, 24
A	---	5, 6, 25, 30-36
A	US 5 517 617 A (SATHAYE SHIRISH S ET AL) 14 May 1996 (1996-05-14) abstract column 2, paragraph 3 - paragraph 5 column 8, paragraph 4 -column 9, paragraph 1 claim 1; figure 2 ---	4-6, 24, 25, 30-36
A	US 5 390 170 A (SUBRAMANIAN RAJAN ET AL) 14 February 1995 (1995-02-14) abstract column 5, paragraph 3 column 30, line 11 -column 32, line 31 column 34, paragraph 1 -----	1, 4, 23-25, 30-36

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 00/24510

### Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
  
3.  Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

#### Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-3,7-23,26-29,37-47

Communication system and method placing each accessing subscriber unit into at least one forward equivalency class

2. Claims: 4-6,24,25,30-36

Communication system and method establishing an ATM virtual connection between new routing element and an existing distribution point

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No

PCT/US 00/24510

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
WO 9826548	A 18-06-1998	US 6012088	A 04-01-2000		
		AU 723550	B 31-08-2000		
		AU 3572697	A 03-07-1998		
		EP 0953248	A 03-11-1999		
WO 9736405	A 02-10-1997	FI 961363	A 26-09-1997		
		AU 2162097	A 17-10-1997		
		CA 2250040	A 02-10-1997		
		CN 1214832	A 21-04-1999		
		EP 0886938	A 30-12-1998		
		JP 2000507416	T 13-06-2000		
WO 9748210	A 18-12-1997	NONE			
US 5517617	A 14-05-1996	NONE			
US 5390170	A 14-02-1995	US 5519707	A 21-05-1996		
		JP 6268747	A 22-09-1994		
		US 5715396	A 03-02-1998		
		US 5664107	A 02-09-1997		
		US 5586267	A 17-12-1996		
		US 5694547	A 02-12-1997		